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THE EFFECTS OF MINING OPERATIONS ON AGRICULTURE IN THE DECKER STUDY AREA

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THE EFFECTS OF MINING OPERATIONS ON AGRICULTURE IN THE DECKER STUDY AREA

By Myles Watts &
Brent Ingebrigtson

Prepared for:

Decker Area Comprehensive Study
Montana Department of State Lands and
U.S. Office of Surface Mining

Prepared by:

Mountain West Research-North, Inc.
Billings, Montana

5 January 1983

TABLE OF CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

This study investigates the impact that three proposed coal mines in southeastern Big Horn County would have on net income from agriculture. The lost agricultural net income resulting from the proposed mines was determined by use of a linear-programming/optimization process. Inputs into the model framework consisted of production estimates, nutritional requirements, prices, costs, and land mix changes over time. An objective function, defined as net return over variable cost, was maximized for each ranch both with and without the proposed mines. The discounted present value of the difference between the with and without net income amounts is the loss of net income due to the mines.

The model estimate indicates that the present value of the total loss of net income to agriculture would be the following:

1) $128,000 for the Wolf Mountain Mine
2) $38,000 for the CX Mine
3) $368,000 for the Youngs Creek/Tanner Creek mines

In all cases, the lost agricultural net income would amount to less than 1 percent of the potential profit or royalties produced by the mines in one year. The loss of net income due to Youngs Creek/Tanner Creek mines would last only for the life of the mines, but for both the Wolf Mountain and the CX mines, the loss of agricultural net income would be permanent. The primary reason for the permanent loss of net income to the CX Ranch is that it would sustain a permanent loss of irrigated hayland due to the mining and reclamation process.

The total lost net agricultural income could be offset by several factors:

1) The loss to the CX Ranch, which is owned by Consolidation Coal, would be replaced by mine income.

2) The loss to the Crow Reservation would be replaced by royalty income.

3) The losses could be lessened by staging the removal of agricultural land from production.

4) The cattle production loss on the Crow Reservation could be mitigated by placing the cattle on land that is currently underutilized elsewhere on the reservation.

5) Eliminate any land loss due to alkali on the Wolf Mountain Mine Site.

6) Reclaim the land with a more balanced combination of hay and grazing land.

7) Increase the productivity of the reclaimed land.

1. INTRODUCTION

1. INTRODUCTION

Most land in the Decker study area is used for ranching. The construction and operation of the three proposed mines would have a direct impact on the production and therefore profitability of the ranching units where the mines are located. The purpose of this study is to identify and quantify the loss of agricultural net income that would occur due to the construction and operation of the proposed mines.

Two ranching units are analyzed:

1) The CX Ranch is the location of both the CX and the Wolf Mountain mines. Therefore, the changes in the net income from the CX Ranch due to the two mines serve as one basis of analysis.

2) The Youngs Creek/Tanner Creek mines are located on the Crow Indian Reservation. Their location is such that no distinct ranching unit can be identified that contains the entire mine site. For this reason, the entire reservation is considered the basis of analysis of lost production due to the mines.

The remainder of this discussion presents the methodology utilized in the analysis, the data inputs of the model, and the results from the analysis. Much of the methodology and data discussion were derived from a report entitled Public and Private Grazing Resources in Montana with Emphasis on Forest Service Administered Grazing (Montana Agricultural Experiment Station 1980). The exact data utilized in the model were analyzed and computed by Mountain West Research to match the specific characteristics of the study area, but the actual model description and process is very similar to the one discussed in the above report.

2. METHODOLOGY AND MODEL DESCRIPTION

2. METHODOLOGY AND MODEL DESCRIPTION

The impact of mining on the affected ranching units is best described and modeled in an optimization framework. The optimization technique allows for the analysis to be conducted in the absence of non-economic influences. Linear programming is a widely recognized technique for optimizing a linear objective function subject to several linear constraints. The linear programming model was applied to each permit area. The model was customized to fit the exact land mix combination that existed at each mine site.

The linear programming model allowed for two production activities: cow-calf and alfalfa hay production. The input requirements were separated into five categories:

1) Cattle feed and nutritional requirements
2) Production levels
3) Labor requirements
4) Prices and costs
5) Land mix for base ranches and mine sites

The cow-calf activity resulted in the sale of calves, cull cows, and replacement heifers. Bulls were treated as a depreciable item. Replacement heifers were generated internally. Alfalfa hay that was raised could be either fed or sold. Alfalfa hay, straw, and/or cow pellets could be purchased for feed. The range and hayland acreages and the AMs[1] available on the base ranch were based upon the information in the mining permit applications.

2.1 Feed and Nutritional Assumptions

The feed requirements for each cow unit were satisfied by grazing or feeding. The grazing occurred for nine months or 269 days, and feeding

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[1]The forage consumed via grazing is measured in animal months (AMs).

occurred for three months or 96 days. For a grazing day, all nutritional requirements were assumed to be met through grazing with no supplemental feeding required. A feed day was a day in which all nutritional needs were met by provided feed, rather than by grazing. Provided feed was selected by the linear programming model to meet the nutritional requirements of the cattle and could include cow pellets (assumed to be purchased), alfalfa hay (available by purchase or raising), or straw (available by purchase). Table 1 shows the nutritional content of each feed.

Allowing straw to be a portion of the diet causes special problems in that the consumption capacity of the cow may be exceeded in order to meet her nutritional requirements. Also, problems in utilizing the nutritional content of the diet are encountered if large quantities of straw are consumed. Therefore, total dry matter intake was limited to 3 percent of body weight (thirty-three pounds), and daily straw dry matter intake was limited to 1 percent of the body weight (eleven pounds). Table 2 presents the nutritional requirements for each cow. These values were computed by multiplying feed days by daily requirements.

Replacement heifer calves were assumed to be weaned on 15 October. Between 15 October and 15 March, the heifer calves were assumed to gain 0.7 lbs per day, weighing 425 pounds at the beginning of the period and 530 pounds at the end of the period. During this period, it was assumed that for 111 days all nutritional requirements were met by provided feed and that, for the remainder of the days, nutritional requirements were met by grazing. Maximum dry matter intake was limited to 3 percent of body weight, and maximum straw dry matter consumption was limited to 1 percent of body weight. Daily and annual nutritional requirements for a 478-pound heifer (average of weight between 15 October and 15 March) gaining 0.7 pounds per day are presented in Table 2.

It was assumed that a bull was required for every twenty-five cows. Daily and annual feed requirements for the bull are presented in Table 2 and were computed in a manner analogous to the replacement heifer.

TABLE 1

Nutritional Content of Possible Provided Feeds

Feed	Dry Matter (Percent)	Total Digestible Nutrients (Percent)	Digestible Protein (Percent)
Alfalfa hay	89	49	11
Wheat straw	90	43	0.4
Cattle pellets	90	74	16

Source: National Academy of Sciences, "Nutrient Requirements of Beef Cattle," Printing and Publishing Office, Washington, DC, 1976.

TABLE 2

Yearly Feed Requirements
Cattle in South-central Montana

Feed	Cow	Heifer	Bull
Minimum Dry Matter (lbs.)	1,697.6	1,219.2	2,217.6
Maximum Dry Matter (lbs.)	3,168.0	1,372.8	5,068.8
Minimum Total Digestible Nutrient (TDN) (lbs.)	931.2	672.0	1,225.0
Minimum Digestible Protein (lbs.)	56.3	64.32	105.6
Maximum Straw (lbs., dry matter basis)	1,056.0	460.8	1,689.6

Source: National Academy of Sciences, "Nutrient Requirements of Beef Cattle," Printing and Publishing Office, Washington, DC, 1976.

The number of AMs a cow consumes in a feeding period is equal to the total number of days in the period minus the days in which feed is provided divided by thirty. Both a cow and a bull were assumed to consume one AM per thirty days of grazing, and a replacement heifer or yearling was assumed to consume 0.7 AM per thirty days of grazing.

2.2 Production Levels

Each production activity (cow-calf and alfalfa hay) produces either a saleable product or an input for another activity. The cow-calf activity is directly associated with grazing, while the alfalfa hay activity may provide both hay and aftermath grazing as inputs to the cow-calf activity. In order to estimate the contribution of grazing to income, it was necessary to correctly include complementary activities.

The cow-calf activity produces calves, cull replacement heifers, and cull cows for sale. Therefore, it was necessary to estimate the portion of cows culled annually and the number of replacement heifers held to replenish the cow herd. (See the Appendix for the herd dynamics formula.)

The number of heifers held for replacement on a ranch with constant cow numbers and replacement is a function of cow death loss, cows culled, replacement heifers culled, and replacement heifer death loss. The replacement heifer death loss was assumed to be 2 percent, and the replacement heifer cull rate 10 percent. In other words, 88 percent of the replacement heifers initially held would be retained until they are two years old and enter the cow herd.

Calves sold were assumed to weigh 438 pounds; cull replacement heifers, 800 pounds; and cull cows, 1,050 pounds.[1] Earlier, a 90 percent weaning rate and a 2 percent cow death loss were assumed. If a

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[1]These figures were based on birth weights, average daily gain, and consumption interaction. The weights used were typical for cow units in southern Montana.

cow dies before the calf is born, the calf is also lost, and if the cow dies after the calf is born, the chances of the calf surviving are very low. Therefore, it was assumed that those cows that died did not wean a calf. As a result, only 89.6 percent of the cows that started a production year were expected to wean a calf. Since the number of heifer calves held for replacement was 19.5 percent of the number of cows, each cow produced on the average 70.1 percent of a calf for sale or 310 pounds of calf (70.1 percent of the assumed weaning weight). As stated earlier, 10 percent of the replacement heifers were assumed to be sold due to culling or 16 pounds of culled yearling sold per cow.[1]

Table 3 presents the assumed production levels.

2.3 Labor Requirements

Estimates of labor requirements are difficult to obtain and are generally arbitrary. A common rule of thumb is that one man can provide sufficient labor for a 200- to 250-cow herd. Using the 250-cow herd estimate and 2,500 man-hours of labor for a man-year of labor, each cow unit would then require 10 hours of labor annually.[2] Labor requirements for alfalfa hay were assumed to be 4.12 hours per acre (Montana Extension Bulletin 1978).

2.4 Prices and Costs

Prices for inputs and products sold were estimated by inflating to 1981 annual prices from 1956 to 1981 and calculating a simple average. Prices were inflated to 1981 dollars by the GNP implicit price deflator. Table 4 features 1956 to 1981 cow and calf prices, indicating an inflated average price of $73 and $44 cwt calves and cows, respectively. These prices were expected to be[3] representative of a

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[1]Proportion of replacement heifer of 0.195 times reduction for death loss of 0.98 times replacement heifer culling rate of 0.1 times weight of 800 pounds.

[2]Consistent with figures used in USDA enterprise budgets.

[3]Cwt = per hundred weight.

TABLE 3

Summary of Assumed Production Levels

Production	Level
Pounds of calf sold per cow unit	310
Pounds of cull cow sold per cow unit	173
Pounds of cull replacement heifer sold per cow unit	16
Tons of hay produced per acre	3.0
AMs of aftermath grazing on hayland per acre	1
AMs of improved pasture per acre	0.275
AMs of grazing land per acre	0.156

Source: Mountain West Research-North, Inc. 1982.

TABLE 4

Historic Product Prices
(1981 dollars)

Year	Calf Prices (cwt)	Cow Prices (cwt)	Hay Prices (ton)	Wage Rate per Hour
1956	51.49	32.42	69.98	
1957	64.40	38.15	50.39	
1958	87.65	49.36	49.54	
1959	77.90	48.65	66.44	
1960	69.03	42.10	69.32	
1961	72.88	41.72	68.12	
1962	80.88	46.17	52.63	
1963	70.77	41.79	49.96	
1964	58.52	35.89	58.52	
1965	63.78	39.08	57.28	
1966	70.11	42.67	65.57	
1967	69.30	41.04	55.09	
1968	68.49	39.32	52.77	3.43
1969	72.94	43.67	53.52	3.48
1970	75.15	43.54	47.62	3.50
1971	76.81	44.85	55.44	3.50
1972	92.92	51.07	61.95	3.59
1973	106.78	63.53	104.40	3.74
1974	51.20	43.28	76.64	3.55
1975	47.49	31.21	64.75	3.37
1976	53.20	36.68	69.59	3.40
1977	57.32	34.21	77.53	3.25
1978	94.43	54.57	61.93	3.26
1979	104.53	61.48	71.35	3.26
1980	83.82	48.90	68.22	3.30
1981	62.70	40.30	50.51	NA
Average	72.48	43.68	62.65	3.43
Prices Used	73.00	44.00	63.00	3.43

Source: Agricultural Statistics 1980; Montana Crop and Livestock Reporting Service 1982; Mountain West Research-North, Inc. 1982.

Note: Inflated by GNP implicit price deflator.
NA = Not available.

long-term average price in 1981 dollars and were used in the linear programming model.

Earlier research (Watts 1978) estimated the relationship between yearling prices and calf prices as:

$$P_c = 3.04132 + 1.26303\ P_{ys}$$

$R^2 = 0.9293$

$S = 0.116$

$t = 10.872$

where:

P_c = calf price

P_{ys} = average yearling price

Using the inflated average calf price of $73.00 cwt yielded an average yearling price of $55.00 cwt.

Hay prices also were estimated by averaging 1956 to 1981 prices inflated to 1981 dollars by the GNP implicit price deflator. Table 4 presents 1956 to 1981 prices for hay. Average inflated prices for hay are $61 per ton. Hay may either be bought or sold in the linear programming model with the difference between the purchase and sale price mainly reflecting transportation costs. Transportation costs were assumed to be $7 per ton; thus, the selling price for hay was $63 and the buying price for hay was $70 per ton. Cattle pellets were assumed to cost $150[1] per ton, and straw was assumed to cost $31.50 per ton.[2]

Ranch labor costs were estimated as the average of the 1968-to-1980 Montana hourly farm wage rate inflated by the GNP implicit price index to 1981 dollars. (The first year this data series was available was

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[1]Public and private grazing resources in Montana with emphasis on Forest Service administered grazing.

[2]One half of hay cost.

1968.) Table 4 presents Montana hired wage rates for the 1968-to-1980 period. The average annual Montana hired wage rate in 1981 dollars was $3.43.

The estimated annual cost (excluding feed and labor) for a cow unit (the cow and associated portion of a replacement heifer and bull) was based upon the GP2 1979 USDA federal budget (see Table 5). The estimated annual cost per cow including the associated portion of a replacement heifer and bull in 1981 dollars is $69.24.

Hay production cost estimates based upon the Montana Extension Bulletin on south-central Montana as of July 1978 are presented in Table 6. The variable cost less labor in the budget for 1978 is $59.17. Adjusted into 1981 dollars by use of the Prices Paid By Farmers Index, the variable cost is $82.17.

2.5 Land Mix and Productivity

An integral input for the LP model was current land use mix on the existing base ranches and the changes that would occur from mining. Table 7 presents the land mix and productivity of each land type for the CX ranch. The Crow Reservation is the other base ranch in the study. It was assumed that the land mix on the reservation would be sufficient to make the land availability constraint nonexistent. The land that was disturbed was the effective constraint for the model on the Crow Reservation. The land productivity for both ranches was derived from the land information provided for the CX ranch in the CX mine permit application.

The mine size, disturbance schedule, and reclamation schedule for each mine were other important inputs into the LP model. In order to facilitate the estimation process, it was assumed that the entire mine site would be eliminated from agricultural production at the beginning of mine construction, and the land would be brought back into production after it was mined and reclaimed. The reclamation period was assumed to be five years. The loss of all the land at the beginning of the mine

TABLE 5

Costs Range for a Cow and Associated Portion of a Replacement Heifer and Bull

Item	Cost per Cow
Salt and minerals	$2.71 - 2.75
Veterinary and medicine	2.96 - 3.99
Tax on animals	2.00 - 2.00
Marketing	2.56 - 3.28
Trucking	1.31 - 2.32
Fuel and lube machine and equipment	7.66 - 12.65
Interest on animals	17.76
Machinery and equipment repair	11.24 - 13.53
Bull depreciation	4.00
TOTAL	54.72 - 58.14
Mean (1979 dollars)	56.79
Mean (1981 dollars)	69.24

Source: U.S. Department of Agriculture, 1979 FEDS Budget.

Note: Above numbers are in 1979 dollars; the LP model is calibrated for 1981 dollars. Therefore, the mean price of $56.79 is inflated to 1981 dollars using the Prices Paid By Farmers Index. The resulting cost figure in 1981 dollars is $69.24.

TABLE 6

Irrigated Alfalfa Hay Variable Costs

Variable Costs	Cost per Acre
Stand establishment	$11.25
Fertilizer and application	8.55
Crop chemicals	2.40
Custom hire	0
Irrigation labor	10.50
Machinery: fuel oil and repairs	18.02
Pickup	3.00
Miscellaneous expense	4.54
Other	0
Interest on Operating Capital	1.01
Machinery Labor	14.13
Total Variable Costs	73.40
Total variable costs less machinery labor (1978 dollars)	59.27
Total variable costs less machinery labor in 1981 dollars[a]	82.17

Source: Montana Cooperative Extension Service Budget, July 1978, Irrigated Alfalfa for South-central Montana, Mountain West Research-North, Inc. 1982.

[a]Inflated by the Prices Paid By Farmers Index.

TABLE 7

CX Ranch Land Mix and Productivity Levels

Land Type	Acres	Productivity Per Acre
Irrigated Alfalfa Hay	347	3 tons or 1 AM
Improved Pasture	466	0.275 AM
Rangeland	23,752	0.156 AM
Other	600	NA
TOTAL	25,165	NA

Source: CX Mine permit application; Jeff Hegner, personal communication, Montana Department of State Lands; Mountain West Research-North, Inc., 1982.

Note: The productivity assumptions are based on current productivity on the ranch. This may not be the optimal productivity.
AM = Animal-month.
NA = Not available.

process would have the effect of making the income loss estimate a worst-case scenario.[1]

Table 8 presents the initial land use mix and the reclamation schedule for each land use for each mine. The reclamation schedule is in mine years, not in calendar years.

2.6 Model Specification

The linear programming matrix is presented in Table 9. The right hand side (RHS) column for the land components was adjusted each run to account for the land mix at specific points in the life of the mine. The LP model will maximize the objective function, which is net income for the ranch, subject to the linear constraints of land, nutritional requirements, and costs. The net income is defined as return over variable costs for the ranching units. The objective function is:

$$NI = -69.24\ CU - 82.17\ H - 150\ BUP - 70\ BUH - 31.5\ BUS + 63\ SHAY + 0.44\ SC + 0.55\ SH + 0.73\ SCA - 3.43\ L$$

Where:

NI = net income, return over variable cost
CU = cow units, which includes cows, replacements, heifers, and bulls
H = hayland in acres
BUP = cow pellets purchased (tons)
BUH = hay purchased (tons)
BUS = straw purchased (tons)
SHAY = hay sold (tons)
SC = cows sold (pounds)
SH = heifers sold (pounds)
SCA = calves sold (pounds)
L = labor purchased (hours)

2.7 Model Performance, Sensitivity Analysis, and Results

The model appeared to perform in a realistic manner. The shadow price (the change in net income with the addition of one unit of input)

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[1]These assumptions would produce a worst-case scenario. The actual schedule of what land would be eliminated each year is available, but remaining parcels near the mine site would be either too small to provide effective forage, too close to the mine site, providing a hazard, or too unmanageable for effective production. (Smith, Gjere, personal communications, 1982.)

TABLE 8

Land Mix and Reclamation Schedule
(acres)

Mine	Initial Use	Year Back into Production (Mine Years)										Final Use
		10	15	20	25	30	35	40	45	50	55	
CX Consol												
Hay	16			14								14
Improved pasture	169		70	214								214
Rangeland	1,720	687	1,087	1,677								1,677
Wolf Mountain												
Hay	54			28	28							28
Improved pasture	151			141	492							492
Rangeland	1,261	33	132	295	917							917
Alkali	--	--	21	22	29							29
Youngs/Tanner Creek												
Hay												
Improved Pasture												
Rangeland	8,935	522	1,392	2,262	3,132	4,002	4,872	5,742	6,612	7,482	8,935	8,935

Source: Land Use and Mine Schedule Maps for CX and Wolf Mountain mines.

TABLE 9

Linear Programming Matrix

													Cow			Heifer			Bull		
	CU	IA	RA	H	HUP	BUH	BUS	SHAY	SC	SH	SCA	L	CP	CH	CS	HP	HH	HS	BP	BH	BS
LH				1																	
LI		3.64																			
LR			6.4																		
CN	1070.88												0.74	0.49	0.43						
CDP	64.75												0.16	0.11	0.004						
CL	1952.24												0.90	0.89	0.90						
CUP	3643.2												0.90	0.89	0.90						
CST	1214.4												0.0	0.0	1.0						
HN	193.2															0.74	0.49	0.43			
HDP	18.49															0.16	0.11	0.004			
HL	350.52															0.90	0.89	0.90			
HUP	394.68															0.90	0.89	0.90			
HST	132.48															0.0	0.0	1.0			
BN	56.35																		0.74	0.49	0.43
BNP	4.86																		0.16	0.11	0.004
BL	102.01																		0.90	0.89	0.90
BU	233.16																		0.90	0.89	0.90
BST	77.72																		0.0	0.0	1.0
AM	11.12	-1	-1	-1																	
LAB	10			4.12								-1									
HAY				-6000		-2000								+1			+1			+1	
STR							-2000								+1			+1			+1
PE					-2000								+1			+1			+1		
SOD	220								-1												
SHE	17.5									-1											
SCA	267.75										-1										
Max. Obj.	-69.24			-82.17	-150	-70	-31.5	+63.0	+.44	+.55	+.73	-3.43									

TABLE 9 (cont.)

Linear Programming Matrix
Definition of Constraints

Constraint	Definition
LH	acres of hayland available
LI	acres of improved pasture available
LR	acres of rangeland available
CN	cow energy requirement (total digestible nutrients)
CDP	cow digestible protein requirement
CL	cow lower bound dry matter requirement
CUP	cow upper board dry matter limit
CST	maximum straw fed to cow
HN	heifer energy required (TDN)
HDP	heifer digestible protein requirement
HL	heifer lower bound dry matter requirement
HUP	heifer upper bound dry matter limit
HST	maximum staw fed to heifer
BN	bull energy requirement (TDN)
BNP	bull digestible protein requirement
BL	bull lower bound dry matter requirement
BU	bull upper bound dry matter limit
BST	maximum staw fed to bull
AM	animal-month
LAB	transfer for labor
HAY	transfer for hay
STR	transfer for straw
PE	transfer for cow pellets
SCO	transfer for selling cow
SHE	transfer for selling heifer
SCA	transfer for selling calves

TABLE 9 (cont.)

Linear Programming Matrix
Definition of Activity

Activity	Definition
CU	cow unit
IA	improved pasture AM
RA	rangeland AM
H	hayland AM
BUP	tons of cow pellets purchased
BUH	tons of hay purchased
BUS	tons of straw purchased
SHAY	tons of hay sold
SC	pounds of cows sold
SH	pounds of heifers sold
SCA	pounds of calves sold
L	hours of labor purchased
CP	pounds of pellets fed to cows
CH	pounds of hay fed to cows
CS	pounds of straw fed to cows
HP	pounds of pellets fed to heifer
HH	pounds of hay fed to heifer
HS	pounds of straw fed to heifer
BP	pounds of pellets fed to bull
BH	pounds of hay fed to bull
BS	pounds of straw fed to bull

Source: Mountain West Research-North, Inc., 1983.

Note: AM = Animal-month.

for the AMs was $12.66 in all cases. The current private lease rate for AMs in the area is between $11 and $12.[1] Therefore, the model approximated the actual conditions in the area.

The shadow prices on the land constraints indicate the sensitivity of the profit function to those constraints. As stated above, the shadow prices include the change in the objective function (net income) with the addition of one unit of input. In all cases, the shadow price on hayland was $99.60 per acre; on improved pasture, $3.48 per acre; and on rangeland, $1.98 per acre. These prices mean that an increase of one unit of irrigated hayland would increase the net profit of the ranch by $99.60. An increase of one acre of improved pasture or rangeland would increase net income by $3.48 and $1.98, respectively.

The net income from the base ranch that was lost as a result of the mines is presented in the remainder of this section. For each mine, the model was used to determine the net income loss at five-year intervals beginning at year ten of the mine. The no-action alternative for the base ranch was the basis of the comparative analysis of net income lost. The model was run to determine the maximum net income of the existing ranch. After the base case was estimated, the land mix was changed at five-year intervals to compute the net income of the ranch with the mines. The difference over time between the no-action estimate and the with-mine estimate represents the total loss of net agricultural income due to the mines. The future values of lost agricultural income were discounted back to present value by use of an average "real" interest rate to ranchers (see Table 10). The discounting process accounted for the time preference of money.

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[1]USDA Montana Statistical Reporting Service 1982.

TABLE 10

Real Interest Rate

Year	PCA Interest	GNP Price Deflator	Net "Real" Interest Rate
1963	6.30	1.50	4.80
1964	6.47	1.50	4.97
1965	6.58	2.20	4.38
1966	6.85	3.20	3.65
1967	7.29	3.00	4.29
1968	7.34	4.40	2.94
1969	7.79	5.10	2.69
1970	8.98	5.40	3.58
1971	7.28	5.00	2.28
1972	7.02	4.20	2.82
1973	8.09	5.70	2.39
1974	9.43	8.70	0.73
1975	8.91	9.30	-0.39
1976	8.24	5.20	3.04
1977	7.88	5.80	2.08
1978	8.83	7.30	1.53
1979	10.71	8.50	2.21
1980	12.81	9.00	3.81
1981	14.76	9.10	5.66
Average	8.50	5.48	3.02

Source: Agricultural Statistics, personal communication, Billings PCA, 1982, Mountain West Research-North, Inc., 1982.

3. CX RANCH

3. CX RANCH

The CX and Wolf Mountain mines are both located on the CX Ranch. Each mine was estimated separately to determine its impacts on the ranch income. Also estimated was the mines' cumulative impact on the net income of the ranch. Since the cumulative impact derived in this way was similar to the summation of the two individual impacts, the cumulative impact discussed in this chapter is the summation of the two separate mines' impacts.

The net income of the ranch without any mining was estimated to be $83,000 annually. The net present value of that income over an infinite planning horizon was estimated at $2,753,000 in 1981 dollars.

Table 11 presents the present values of the ranch income with the mines. The present value of the future net income of the ranch with the Wolf Mountain Mine would be $2,625,000. Therefore, the total present value of the lost net income due to the Wolf Mountain Mine would be approximately $128,000. The present value of the future ranch net income with the CX Mine would be $2,716,000. Therefore, the total present value of the ranch income lost due to the CX Mine would be approximately $38,000. The cumulative loss (in present value) of income for the ranch if both mines were built would be approximately $166,000.

In both mine plans, the lost profit (from the agricultural operation) is a permanent condition. The maximum potential annual net income from the ranch after the Wolf Mountain Mine has been completed would be $81,000, reflecting a permanent loss of $2,000 or $0.08 per acre. This loss is due primarily to the permanent loss of twenty-six acres of irrigated hayland and the introduction of twenty-nine acres of alkali, which have no productive value. The permanent loss of net income as the result of the CX Mine would be less than $1,000 annually, attributable to the loss of two acres of hayland. The lost hayland in both cases would have a detrimental impact on the net income of the ranch because the

TABLE 11

Present Value of Lost Net Income from Mines on CX Ranch
(1981 dollars)

Year	Wolf Mountain Net Income Actual	Wolf Mountain Present Value Net Income	CX Mine Net Income Actual	CX Mine Present Value Net Income
1985	$74,760		$77,580	
1986	74,760		77,580	
1987	74,760		77,580	
1988	74,760		77,580	
1989	74,760		77,580	
1990	74,760		77,580	
1991	74,760		77,580	
1992	74,760		77,580	
1993	74,760		77,580	
1994	74,760	$656,307	77,580	$681,063
1995	74,830		78,940	
1996	74,830		78,940	
1997	74,830		78,940	
1998	74,830		78,940	
1999	74,830	262,042	78,940	276,434
2000	75,020		79,970	
2001	75,020		79,970	
2002	75,020		79,970	149,084
2003	75,020		83,030	
2004	75,020	226,394	83,030	
2005	78,630		83,030	
2006	78,630		83,030	
2007	78,630		83,030	
2008	78,630		83,030	
2009	78,630	204,488	83,030	
2010	81,080		83,030	
2011	81,080		83,030	
2012	81,080		83,030	
2013	81,080		83,030	
2014	81,080		83,030	
2015	81,080	1,276,051	83,030	1,609,312
Total Present Value		2,625,283		2,715,894
No-action Present Value		2,753,642		2,753,642
Net Loss Present Value		128,357		37,748

Source: Mountain West Research-North, Inc., 1982.

ranch in the no-mine setting is a net seller of hay. Therefore, any permanent loss of hayland would decrease the net income of the ranch because it would reduce the amount of hay available for sale.

It should be noted that the CX Ranch is owned and operated by Consolidation Coal; therefore, the loss of net income from agriculture to the owners would be offset by increases in coal income. The yearly net income from the mines could potentially be approximately $2.5 million compared to a total loss of net agricultural income of $166,000 or less than 1 percent of one year's potential net mining income.[1]

Agricultural income losses could also be reduced by staggering the loss of land to mining instead of taking all of the permit area out of production at the start of the mine construction.

Under the no-impact scenario, the CX Ranch would raise 374 cow units at its profit maximization condition. The changing land mix due to the Wolf Mountain Mine would produce a maximum loss of 26 units in any one year. The changed combination of grazing and improved pastureland in the final land use mix would allow for one additional unit on the ranch after the mine. The largest loss in any one year of cow units due to the CX Mine was estimated at 30 units. The maximum cow units after the mine is completed would be 374 units.

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[1]Assumes 11 million tons per year mined, with an average coal price of $15 per ton and a profit margin of 15 percent of gross income.

4. CROW RESERVATION

4. CROW RESERVATION

The loss of income to the Crow Reservation "ranch" due to the Youngs Creek and Tanner Creek mines becomes a linear function of the number of acres placed back into production after mining. As stated earlier, the land mix of the entire reservation is assumed to be such that the mine site does not impose a constraint. Therefore, the model was run to directly determine the loss of profit that would be caused by the mine. Table 12 presents the income loss, in present value, due to the proposed mines. The total loss would amount to $368,000; for every acre on the reservation that would be out of production each year, the ranch would lose $1.98 in net income.

The mine site would be restored to the exact land mix that existed before the mining activity. Therefore, there would be no permanent loss of agricultural income to the reservation due to the mine. The maximum loss would be 125 cow units. The ranch would be able to increase production by 1 unit for every 72 acres that came back into production.

This loss of agricultural net income could be supplemented by royalties paid to the tribe. The yearly royalty payment to the Crow could amount to $34.8 million. The total loss of agricultural net income could be $368,000 or about 1 percent of one year's potential royalty payment.[1]

The impacts could be reduced by staggering the loss of land to mining instead of taking all of the permit area out of production at the beginning of mine construction. It might also be possible to move the displaced cows to another part of the reservation that was not operating at capacity at the time.

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[1]Assumes 18 million tons of coal mined per year, with a price of $15.50 per ton and a royalty rate of 12.5 percent.

TABLE 12

Present Value of Lost Net Income to Crow Reservation
from Youngs Creek and Tanner Creek Mines
(1981 dollars)

Year	Lost Net Income	
	Actual	Present Value
1988	$17,673	
1997	17,673	$155,152
2002	16,641	58,274
2007	14,920	45,025
2012	13,199	34,326
2017	11,478	25,725
2022	9,757	18,845
2027	8,037	13,376
2032	6,256	8,974
2037	4,594	5,680
2042	2,874	2,638
2043	0	0
Total Loss Present Value		368,016

Source: Mountain West Research-North, Inc. 1982.

5. SUMMARY

5. SUMMARY

The lost net agricultural income resulting from the proposed mines was determined by use of a linear programming/optimization process. Inputs into the model framework consisted of production estimates, nutritional requirements, prices, costs, and land mix and changes over time. An objective function, defined as net return over variable cost, was maximized for each ranch with and without the mines. The difference between the with and without net income amounts is the loss of net income due to the mines.

The model estimation indicated that the present value of the loss of net income due to the Wolf Mountain Mine be $128,000 over the infinite planning horizon. The loss due to the CX Mine would be $38,000, and the loss due to the Shell mines would be $368,000. The CX Ranch would sustain a permanent loss of net income due to the mines, primarily because of the loss of irrigated hayland. The Crow Reservation would not have any permanent loss of agricultural income. Wolf Mountain Mine would result in a loss of 26 units. The loss due to the CX Mine would be 30 units. The loss due to the Shell mines would be 125 units. In no case would the cattle loss be permanent.

The cumulative loss of net ranching income from the three proposed actions would be limited to $534,000 in present value 1981 dollars. Approximately 69 percent of this income loss would take place on the Crow Reservation. The Wolf Mountain Mine would account for 24 percent; the CX Mine, 7 percent.

APPENDIX

Derivation of Herd Dynamic Statistics

Definition of Variables and Assumed Values when Appropriate:

$TC(i)$ = total females age i or older

$C(i)$ = total females age i

n = mandatory cull age = 11

Y_1 = proportion of females leaving herd between age 0 and 1 = .12

Y_2 = proportion of females leaving herd between age 1 and 2 = .15

Y = proportion of females leaving herd $i>2$ (excluding age culling) = .12

a_2 = proportion of $C(1)$ not weaning a calf at age 2 = .12

a = proportion of $C(i-1)$ not weaning of calf at age i $(i\geq 2)$ = .10

B_1 = miscellaneous culls at age 1 as a proportion of $C(0)$ = .10

B_2 = miscellaneous culls at age 2 as a proportion of $C(1)$ = .03

B = miscellaneous culls at age i as a proportion of $C(i-1)$ where $i\geq 3$ = .02

d_1 = proportion of $C(0)$ lost to death = .02

d_2 = proportion of $C(1)$ lost to death = .02

d = proportion of $C(i)$ lost to death where $i\geq 2$ = .01

Note on age variable i, i is measured in the fall of year after sale; that is, i=0 for calves 7+ months old, i =1 for heifers 1 year and 7 months old, etc.

Therefore,

$$TC(i) = \sum_{j=i}^{n-1} C(j)$$

$$C(j) = C(J-1)(1-y) \quad j>2 \qquad C(2) = C(1)(1-y_2) \quad C(1) = C(0)(1-y_1)$$

$$C(j) = C(k)(1-y)^{j-k} \quad k\geq 2$$

$$TC(i) = C(i)\left[\frac{1-(1-\gamma)^{n-i}}{\gamma}\right] \qquad i \geq 2$$

$$TC(1) = C(1)\left[1+\frac{(1-\gamma_2)[1-(1-\gamma)^{n-2}]}{\gamma}\right]$$

$$C(0) = \frac{TC(1)}{1-\gamma_1}\left[1+\frac{(1-\gamma_2)[1-(1-\gamma)^{n-2}]}{\gamma}\right]^{-1}$$

$C(0)$ = number of replacement heifers (setting $TC(1) = 1$ to develop as proportion of cows) = $.19453 \approx .195$

Yearling Sales

$= \beta_1\ C(0) = .0195 \approx .02$

Cow Sales

$= (\gamma_2 - d_2)\ C(1) + (\gamma-d)\ TC(2) + (1-d)\ C(10) = .16536 \approx .165$

Note: $(\gamma_2-d_2)\ C(1)$ = number of 2 year olds sold

$(\gamma-d)\ TC(2)$ = number 3 through 10 year olds sold

$(1-d)\ C(10)$ = number of 11 year olds sold

Total Calves

$C(1)(1-\alpha_2) + TC(2)(1-\alpha) = .8966$

Steer Calves for Sale $= \frac{.8966}{2} = .4483 \approx .448$

Heifer Calves for Sale $= \frac{.8966}{2} - .195 = .2533 \approx .253$

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